BIOLOGICAL EVALUATION OF GYPSY MOTH

at

Patuxent Wildlife Research Center

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On November 4, 5 and 7, 2002, USDA Forest Service personnel conducted a gypsy moth egg mass survey at Patuxent Wildlife Research Center (PWRC) to assess the potential for defoliation and the need for treatment in 2003. Current populations are sufficient to cause noticeable defoliation on approximately 3,339 acres. Treatment is recommended to prevent defoliation and mast failure and possible tree mortality.

METHODS

Gypsy moth survey plots were randomly selected based upon available host trees (oak species), size of sample area and uniformity between egg mass counts. At each sample point, a 1/40th acre fixed radius plot was established. The plots consisted of a tally of all new (2002) egg masses observed on overstory trees, understory vegetation, ground litter and duff. The total number of egg masses observed for each plot was multiplied by 40 to determine the number of egg masses per acre.

Egg mass length was measured at most of the plots to determine the overall "health" of the existing population and as a measure of egg mass fecundity. The average egg mass length (measured in millimeters) and egg mass density (egg masses per acre) were used to estimate defoliation potential (Liebhold et al., 1993).

RESULTS

The location of the survey plots are shown in Figure 1. The summarized results of the survey are presented in Table 1. Egg mass densities throughout PWRC ranged from 0-15,040 and averaged 1,280 egg masses per acre. Most of the areas that are heavily infested by gypsy moths are located on the North Tract. Overall egg mass lengths tend to be large to extra large in size, ranged from 18-52 mm and averaged 32 mm.

DISCUSSION

The basic guidelines used to evaluate the risk of defoliation include: previous defoliation events; number of egg masses/acre; size and condition of the egg masses; available preferred food; and risk of larval blow-in following egg hatch. Potential defoliation is categorized as; light (1-30 percent); moderate (31-60 percent); and heavy (61-100 percent).

The survey results indicate that areas of noticeable defoliation (moderate and or heavy) is likely to occur in four areas encompassing 3,339 acres at PWRC in 2003 (Figure 2.). Three of these areas are located on the North Tract while the other is located on the South Tract.

This defoliation prediction is further supported when egg density is also used as a means of estimating gypsy moth population densities. Moore and Jones (1987) found that estimating the mean fecundity would increase the precision of gypsy moth density estimates and that a linear relationship exists between egg mass length and fecundity. Further work by Liebhold et al., (1993) demonstrates that the product of the mean egg mass length (mm) and egg mass density provides a more precise means of estimating population densities and predicting defoliation. Using Liebhold's model, Figure 3 shows how this information can be used to correlate the predicted defoliation of an area. Accordingly, the estimated egg mass density of 2,857 egg masses per acre (average egg mass density of the largest block on the North Tract) x 32 mm

(average egg length) translates to a projected defoliation level of about 72 percent (heavy defoliation). Because egg mass densities and host type are not evenly distributed, actual defoliation will vary from tree to tree but will be predominately heavy throughout this area of PWRC. Moderate defoliation (38 and 41 percent, respectively) is projected in the other two blocks on the North Tract. Moderate defoliation (59 percent) is also projected in the block on the South Tract.

Based on existing egg mass densities and the general size of egg masses, gypsy moth populations appear to be building and healthy throughout most areas surveyed at PWRC. The average egg mass length is 32 mm. Egg masses larger than 25 mm typically indicate healthy populations with no obvious sign of stress from either the gypsy moth nucleopolyhedrosis virus (NPV) or the *Entomophaga maimaiga* fungus, two of the primary natural control agents that often express themselves in declining or stressed populations. There was no evidence that either one of these entomopathogens had significant impacts at PWRC in 2002. Although it is still possible that either the gypsy moth fungus or the NPV could cause a general collapse next year, it is not likely to occur prior to a significant defoliation event occurring in 2003.

Predicting the extent of tree mortality that would result after one year's defoliation is difficult, however, a stand of trees that is not stressed by other agents during or immediately following a single heavy defoliation will likely pull through with only minor branch dieback and minimal mortality. Trees that are defoliated in excess of 60 percent normally refoliate the same growing season. Such events cause the trees to expend valuable energy reserves to refoliate, and consequently cause the trees' health to deteriorate. Depending on the condition of the trees at the time of defoliation, reduced growth, mast abortion, branch dieback or in some cases tree mortality, has occurred following a single year of heavy defoliation. Should subsequent defoliation occur the following year, the impact is compounded. Trees that receive light-moderate defoliation (< 60 percent) are not likely to refoliate and there is probably no significant impact other than a reduction in growth, reduction of mast and possibly some minor branch dieback.

Trees at greater risk are those that are presently stressed from other factors, such as soil compaction from roads, sidewalks, parking lots, machinery and/or heavy foot travel; over maturity; drought; shock due to recent timber cutting activities; previous year(s) defoliation; and other insect and disease related problems. A severe drought was experienced in this portion of Maryland during the summer months in 2002. Also, approximately 35 acres of moderate defoliation and 23 acres of heavy defoliation were detected at PWRC in 2002 (Figure 4).

Gypsy moth defoliation also has a significant impact on mast production. The potential loss of acorn mast was demonstrated by McConnell in 1988 (Gottschalk, 1990). His study found that moderate defoliation reduced production by about 50 percent and heavy defoliation near 100 percent. Other studies conducted by the Pennsylvania Game Commission had similar results and found that reduced acorn production continued for 1-2 years following the last year of defoliation.

The Allegheny National Forest (1988) and the West Virginia Division of Forestry (1997) and the Cuyahoga Valley National Park (2002) provide examples of potential tree mortality. On the Allegheny National Forest, untreated stands consisting of 40-80 percent oak, the average loss of basal area (mainly oaks) was about 16 percent (range 3-28 percent) following one year of

defoliation and 26 percent (range 10-43 percent) after two consecutive years of defoliation. In a 1986 study area in eastern West Virginia where oak species accounted for 63-78 percent of the species composition, a loss of 25 percent of the total oak sawtimber and 14 percent of the total oak poletimber occurred after one year of moderate to heavy defoliation. At Cuyahoga Valley National Park following one year of heavy defoliation, significant mortality occurred in approximately 25 percent of the defoliated areas. In the mortality areas, oak mortality ranged from 22-98 percent and averaged 54 percent. In these examples, droughty conditions likely contributed to the level of mortality.

Based on observations of the existing health of the forested areas at PWRC and the factors mentioned above, large areas of extensive tree mortality are not expected should defoliation occur in the absence of drought conditions in 2003.

Management Options

For 2003, two management options have been evaluated for managing gypsy moth populations at PWRC. The intervention options are offered based upon the following two treatment objectives: 1) protect host tree foliage and prevent mast failure and tree mortality; and 2) reduce gypsy moth population below the treatment threshold. Each is discussed below.

No Action Option

It is possible that gypsy moth populations could collapse on their own due to the presence of nucleopolyhedrosis virus (NPV) or the more recently recognized fungal pathogen, *Entomophaga maimaiga.* In areas with defoliating levels of gypsy moth populations (greater than 750 egg masses per acre) viral epizootics generally manifest themselves after significant tree defoliation has already occurred. Gypsy moth populations will usually peak in 2-3 years once they reach levels and then collapse as a result of NPV or fungal activity. Residual populations following such a collapse will likely remain at low densities for 3-6 years before rebuilding to defoliating levels.

Although it is not possible to accurately assess such events with information at hand, it is unlikely that a collapse will occur prior to defoliation since most of these areas are newly infested and there is an abundance of large healthy egg masses.

Large numbers of gypsy moth caterpillars and defoliation has been shown to impact competing native herbivore arthropods. Sample et al. (1996) showed short-term impacts of both species richness and abundance occurred following light to moderate defoliation events in study plots in West Virginia. It is likely that impacts would be greater as the size of the area and intensity of defoliation increases and be more long term, should extensive tree mortality occur.

Should this option be selected, it is likely that noticeable defoliation will occur in four areas located at PWRC in 2003.

Microbial Insecticide Option

***Btk*:** The only biological insecticide currently registered and commercially available for gypsy moth control is the microbial insecticide *Bacillus thuringienis* variety *kurstaki (Btk)*. This insecticide is available through several manufacturers and has been used extensively in suppression projects throughout the U.S. in both forested and residential areas. *Btk* is a bacterium that acts specifically against lepidopterous larvae as a stomach poison and therefore must be ingested. The major mode of action is by mid-gut paralysis, which occurs soon after feeding. This results in a cessation of feeding, and death by starvation. *Btk* is persistent on foliage for about 7-10 days.

Btk has been shown to impact other non-target caterpillars that are actively feeding at the time of treatment. An example of the potential impacts is provided by a study conducted by Miller (1990) in Oregon and Samples, et al. (1996) in West Virginia. Miller's study involved a large-scale (5,000 acres) eradication program where three consecutive applications of *Btk* were applied within a single season. On Garry oak, Miller found that species richness was significantly reduced in treated areas during all 3 years of the study while the total number of immature native Lepidoptera rebounded after the second year. In the Sample study, the areas treated with *Btk* were 50 acre plots and only a single treatment applied. Here too, both species richness and the total numbers of native macro-lepidopterous caterpillars and adults were reduced but only for less than 1-year. The difference in duration of the impacts between these studies is probably the result of the number of treatment applications applied and the size of the treatment area involved.

Btk formulations are available as flowable concentrates, wettable powders, and emulsifiable suspensions. The normal application rates range from 24-36 billion international units (BIUs) per acre in a single or double application. *Btk* can be applied either undiluted or mixed with water for a total volume of ½-1 gallon per acre. With proper application, foliage protection and some degree of population reduction can be expected with one application and with two applications both foliage protection and a greater degree of population reduction are likely.

Because *Btk* is a biological insecticide, the degree of population reduction varies and may depend on, at least in part, the selected application rate, relative health of the population (building vs. declining), population densities, weather (rain and temperature), the feeding activity of the larvae following treatment, and the actual potency of the product.

Gypchek: A second microbial insecticide that is registered and available in limited quantities is the formulated nucleopolyhedrosis virus called Gypchek. This product is not available commercially but is produced in limited quantities by a cooperative effort of the USDA Forest Service and the Animal Plant Health Inspection Service (APHIS). The active ingredient in Gypchek formulations has a very narrow host range (lymnatriids) and occurs naturally in gypsy moth populations. Normally the virus reaches epizootic proportions when gypsy moth populations reach high densities as a result of increased transmission within and between gypsy moth generations. The application of Gypchek to gypsy moth populations simply expedites this process by increasing the exposure of the virus at an earlier stage. Healthy, feeding gypsy moth caterpillars become infected by ingesting contaminated foliage and soon stop feeding and die.

The efficacy of Gypchek treatments to reduce gypsy moth populations has been quite variable. Because of the short period of viral activity on foliage (3-5 days) as well as other biological factors such as feeding activity and weather conditions, it has been difficult at best to project treatment efficacy. Most often foliage protection is achieved but significant reductions in gypsy

moth densities do not always occur. Should inadequate population reduction occur, areas would need to be treated again the following year.

The normal application rate of Gypchek is 2×10^{11} occlusion bodies (OB's) per acre applied in two applications, or a single application at 4×10^{11} OB's. Due to the limited supply, priority is first given to state and federal cooperators that need to deal with federally listed threatened and endangered species associated with gypsy moth treatments. There are, however, sufficient quantities of Gypchek currently available for 2003 should this insecticide be preferred for use at PWRC.

Alternatives

With the previously described options in mind, the following alternatives are offered.

Alternative 1	- No action
Alternative 2	- One aerial application of *Btk* at the rate of 36 BIUs in a total mix of ¾ gallon per acre.
Alternative 3	- Two aerial application of *Btk*, as in alternative 2, applied 4-7 days apart.
Alternative 4	- One aerial application of Gypchek at the rate of 4×10^{11} OB's in a total mix of 1 gallon per acre.
Alternative 5	- Two aerial applications of Gypchek at the rate of 2×10^{11} OB's in a total mix of 1 gallon per acre, applied 3-5 days apart.

RECOMMENDATIONS

As previously stated, gypsy moth populations are healthy, building and sufficient to cause noticeable defoliation on 3,339 acres at PWRC in 2003 (Figure 2). To protect host tree foliage and prevent mast failure and tree mortality, our recommendation is Alternative 4 (a single application of Gypchek). This recommendation is based on the following conditions:

1. The use of Gypchek minimizes the risk to other non-target organisms including lepidopteran caterpillars.

2. A single application of Gypchek will likely provide adequate foliage protection and reduce the existing population below the treatment threshold throughout most of the treatment area.

3. The cost of a single application of Gypchek is about one half that of a double application of Gypchek.

Only small and scattered areas of defoliation, if any, are expected elsewhere at PWRC in 2003.

Table 1 – Results of the gypsy moth egg mass survey conducted at Patuxent Wildlife Research Center on November 4, 5 and 7, 2002.

Plot Number	Number EM/Acre	Plot Number	Number EM/Acre
1	0	34	0
2*	720	35*	520
3*	15,040	36*	1160
4*	2,760	37*	3,720
5*	1,960	38*	2,080
6*	3,320	39*	5,320
7*	1,040	40	0
8*	1,520	41*	0
9*	2,160	42*	40
10*	920	43	80
11*	1,360	44*	680
12*	40	45*	2,920
13*	10,640	46*	2,520
14*	2,480	47	0
15*	400	48	0
16*	1,280	49	0
17	0	50	0
18	0	51	0
19*	0	52*	160
20	0	53*	560
21*	240	54*	800
22*	880	55*	4,680
23*	4,080	56*	360
24*	3,320	57*	3,360
25*	13,080	58*	560
26*	0	59	120
27*	3,680	60	0
28*	2,080	61	0
29*	200	62	0
30*	720	63	40
31*	720	64	80
32	0	65	0
33	0	66	0

Table 1 (continued) Results of the gypsy moth egg mass survey conducted at PWRC on November 4, 5 and 7, 2002.

Plot Number	Number EM/Acre	Plot Number	Number EM/Acre
67	0	75	0
68	0	76	0
69	0	77	0
70	0	78	0
71	0	79*	400
72	0	80	120
74	0	82	0

Overall egg mass/acre range = 0-15,040
Overall egg mass/acre average = 1,280

Egg mass size range (mm) = 18-52
Egg mass size average (mm) = 32

* = Located within proposed treatment blocks

Egg mass/acre range in proposed treatment blocks = 0-15,040
Egg mass/acre average in proposed treatment blocks = 2,322

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Figure 1.--Gypsy moth egg mass survey plot locations at Patuxent Wildlife Research Center, November 4, 5 and 7, 2002.

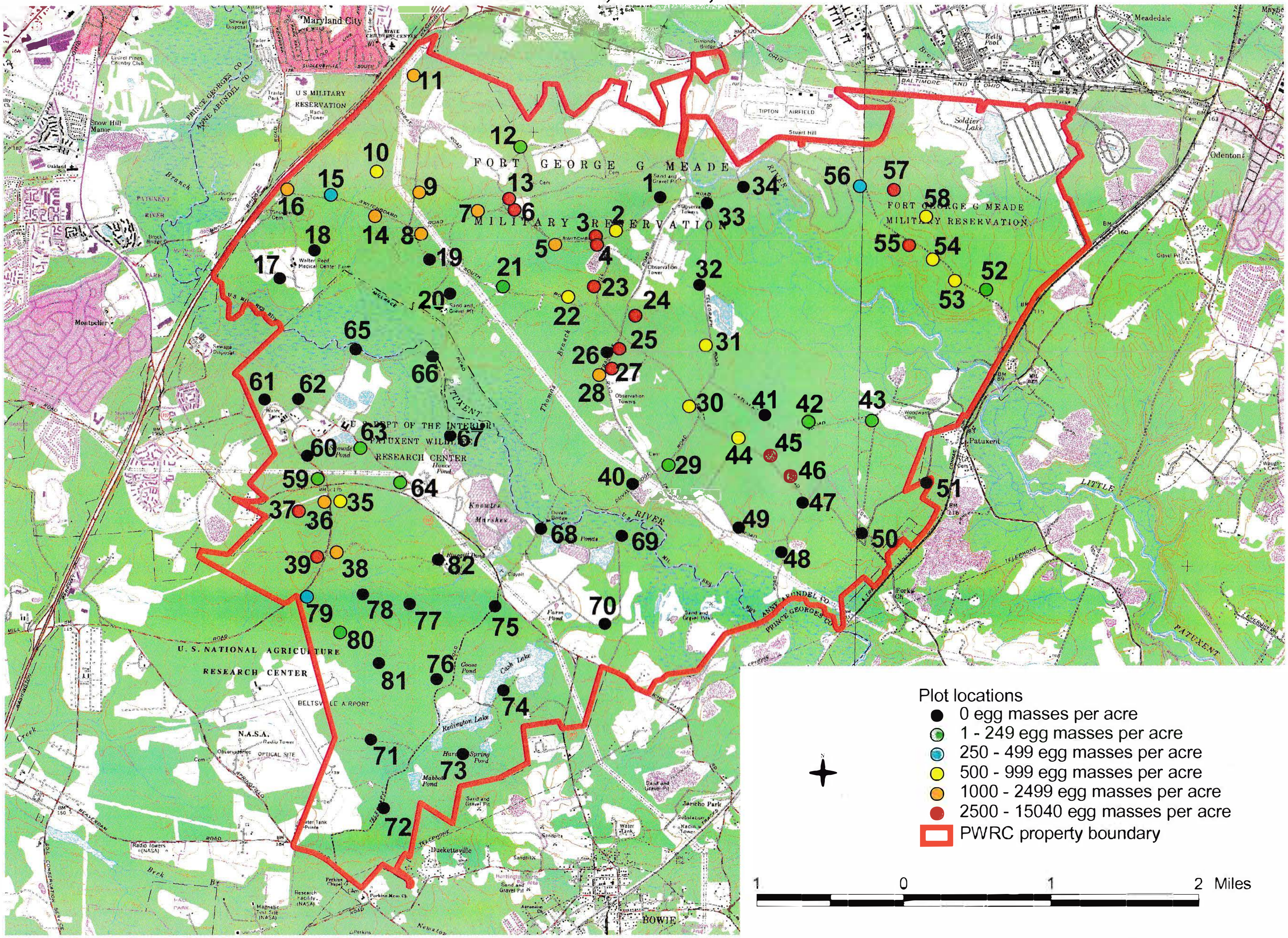

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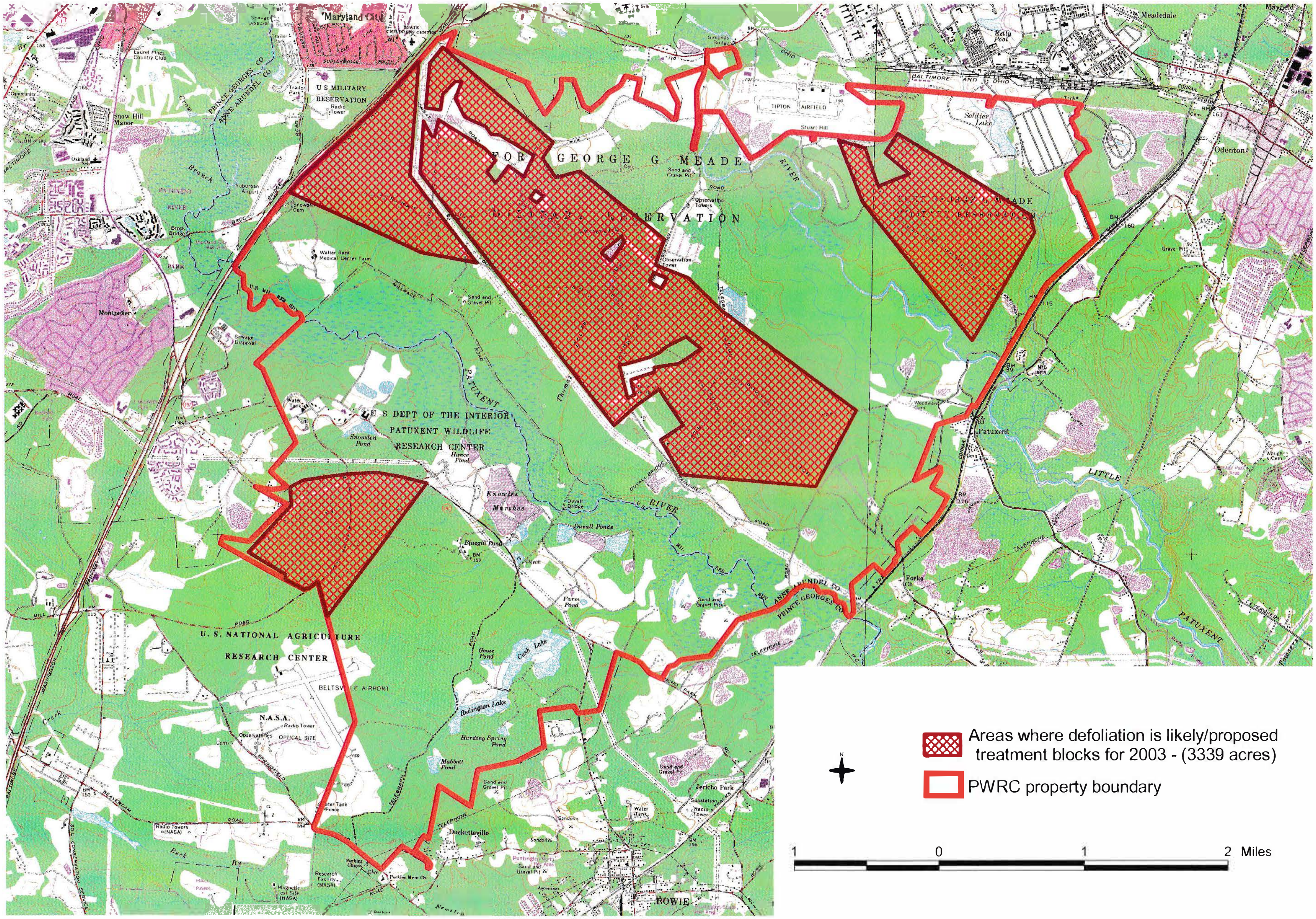
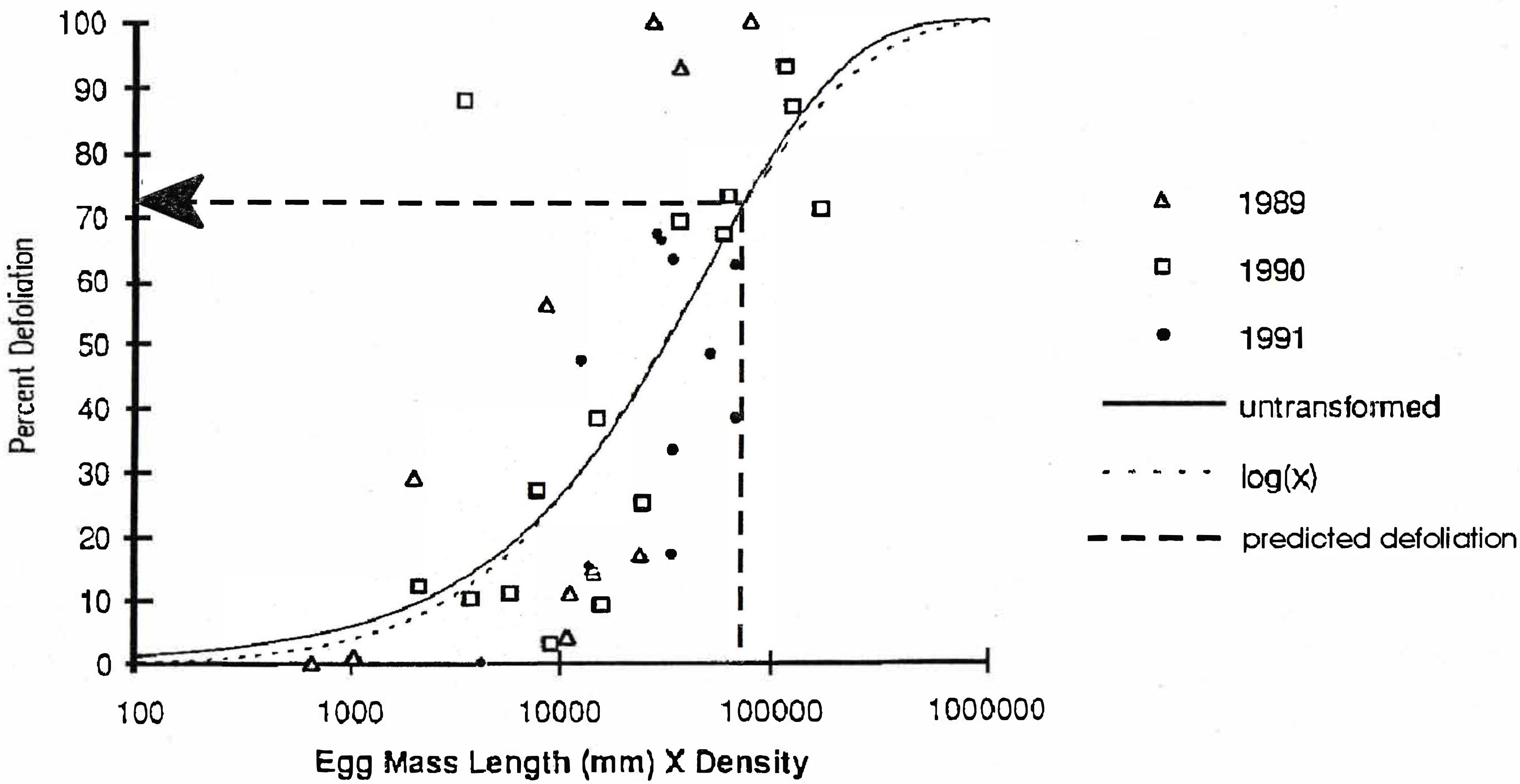
Figure 2.--Areas where gypsy moth defoliation is likely/proposed treatment blocks for 2003 at Patuxent Wildlife Research Center.



USDA Forest Service, FHP, S&PF, Morgantown, WV

12/02 KDF

Figure 3.--Predicted defoliation in the largest block on the North Tract at Patuxent Wildlife Research Center in 2003.



Scatter plot of the product of mean egg mass length and egg mass density versus mean defoliation. Extracted from Liebhold et al. (1993).

Figure 4. -- Results of the aerial detection survey conducted on June 12, 2002, at Patuxent Wildlife Research Center.